Exploring the Role of Letter Length on RTs in a LDT: Evidence from 3, 4, 5, 6, 7 Letter Words in Turkish

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Submitted to the
Institute of Graduate Studies and Research
in partial fulfillment of the requirements for the degree of

Master of Science
in
General Psychology

Eastern Mediterranean University
July 2025
Gazimağusa, North Cyprus

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ABSTRACT

The significance of word letter length on processes involved in visual word recognition, therefore, on reading have been reported on English since the 1970s (Forster & Chambers, 1973; Weekes, 1997). The finding that in experimental tasks, such as naming and lexical decision, reaction times (RTs) increase as a direct function of increased letter length has attracted much interest from both theoretical and applied domains. Although the literature on this topic is Anglo-centric and rather limited across languages, in Turkish it is almost non-existent apart from a preliminary naming experiment. Word length effect findings in Turkish were explained by the Dual-Route Cascaded (DRC) model as such that a lexical route is assumed to be used primarily to read all words while the Parallel Distributed Processing (PDP) models explain the results as each particular word is associated with a particular sound pattern of activation across a common set of units that are used to process all words. The current study aimed to examine the extent to which word letter length influences RTs in a lexical decision task (LDT) in Turkish with adult native Turkish speakers (N= 150). The Linear Mixed Effect Analysis showed that early acquired words had significantly faster RTs than late acquired words. Although overall a non-significant effect was found for length, nevertheless as letter length increased RTs increased for non-words but not for words. The findings and their implications for Turkish are discussed within the current theoretical models with the aim to pave the path for future experiments.

Keywords: Word length effect, age of acquisition, lexical decision task, psycholinguistics.

ÖZ

Görsel sözcük tanıma veya okuma süreçlerinde sözcük harf sayısının okuma süresindeki etkisi, 1970'lerden bu yana İngilizce'de yapılan çalışmalarda ortaya konmuştur (Forster & Chambers, 1973; Frederiksen & Kroll, 1976). Ancak bu konuya dair literatür, büyük ölçüde İngilizce merkezlidir ve diğer dillerde oldukça sınırlıdır. Sözcük harf sayısının okuma süresini etkilemesi Çift Rota Modeline göre (DRC, Colhear vd., 2001) teorik olarak aşina sözcüklerin okunmasında öncelikli olarak doğrudan sözcüksel bir rota kullanıldığı halde harf sayısının bundan bağımsız olarak fonolojik bilgiye dayalı veya dolaylı rotadan kaynaklandığını savunur. Türkçe'de ise, bu alanda bir adlandırma deneyi dışında (Kökten & Raman, 2007) neredeyse hiç çalışma bulunmamaktadır. Bu deneyin amacı, Türkçe'de sözcük edinim yaşına (SEY) göre seçilen 3, 4, 5, 6 ve 7 harf uzunluğuna sahip sözcüklerin, sözcüksel karar verme görevindeki (SKVG) tepki sürelerini (TS) ne ölçüde etkilediğini incelemektir. Aynı zamanda SEY'nin, kelime sıklığı efektine benzer bir etki yapıp yapmayacağı da incelenmektedir. Katılımcıların SKVG TS'leri Jamovi programında lme4 paketi kullanılarak analiz edilmiştir. Lineer Karma Etkiler Analizi (LMM), sözcüğün harf sayısı arttıkça katılımcıların anlamlı şekilde daha uzun sürede yanıt verdiklerini göstermese de lineer bir trend gözlemlenmiş ve erken edinilen sözcüklerin, geç edinilen sözcüklere göre daha kısa TS ortaya koyduğunu göstermiştir. Bulgular ve Türkçe'ye yönelik çıkarımları, güncel kuramsal modeller çerçevesinde tartışılmakta ve gelecekteki deneylere zemin hazırlaması hedeflenmektedir.

Anahtar Kelimeler: Sözcük uzunluğu etkisi, sözcük edinim yaşı, psikodilbilim, sözcüksel karar verme görevi.

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RT	Reaction Times
DRC	Dual Route Cascaded
PDP	Parallel Distributed Processing
LDT	Lexical Decision Task
AoA	Age of Acquisition
VWR	Visual Word Recognition
HF	High Frequency
LF	Low Frequency
NW	Non-words
IA	Interactive Activation
NT	Naming Task
GPC	Grapheme-phoneme-correspondence
ODH	Orthographic Depth Hypothesis
HGT	Hypothesis of Granularity and Transparency
PGST	Psycholinguistic Grain Size Theory
Ms	Miliseconds
EMU	Eastern Mediterranean University

Chapter 1

INTRODUCTION

1.1 Background and Context

Contrary to speaking, which is a universal skill humans developed through evolution, reading is a product of the culture that is learned through observation, instruction and practice (Rastle, 2016). Reading has been a topic of interest since the early days of psychological research (Cattell, 1886; Huey, 1908) and exploring the functional mechanisms involved in this skill and the factors that influence reading continues to be a focal point of modern psycholinguistics research in many areas such as reading development (Skaftun, 2011), reading difficulties (Nation, 2019) and skilled reading (Besner & Coltheart, 1979). in which Revealing the underlying processes in reading is important to achieve higher literacy counts through better instructions which is why it is important to examine the factors such as frequency effect, AoA (Age of Acquisition) etc. (Duke & Cartwright, 2021) that contribute to this process.

Visual word recognition (VWR) is an essential part of reading which requires rapid and efficient processing of written symbols (i.e., words). During VWR skilled readers can perceive words through a combination of bottom-up and top-down processes. Bottom-up processes involve analysing visual cues by sensory processes (i.e., orthographic analysis), subsequently, pathways involved with morphology, phonology, and semantics get activated (Grainger, 2008). This leads to activation of their representations by accessing the mental lexicon (i.e., the internal dictionary in the brain) where word representations are stored (Norris, 2013). Consequently, many word representations get activated at the same time, however, if a certain activation threshold for a word is achieved that word wins the competition between its perceptually neighbour words which is a top-down process (i.e., lexical competition). Combining this information with contextual cues, after accumulating necessary evidence, skilled readers could achieve meaning through these processes.

VWR is one of the most studied (if not the most) topics in reading and has had a major impact on cognitive psychology's emergence. However, regarding Turkish psycholinguistics research in general, the scientific literature is limited in experimental studies and there are countless research questions worth pondering regarding skilled reading. At this point, it is of importance to clearly state that the proposed thesis' focus of investigation will be on the visual recognition of single words in an alphabetic language with skilled Turkish readers, which is an extremely transparent (i.e., highly consistent print to sound correspondences) writing system (Raman E., 2021). Moreover, word length effect and AoA effect will be the variables of interest in this investigation. Before diving into theoretical considerations, the following section will provide some of the significant variables that VWR models consider.

1.2 A Review of Key Psycholinguistic Variables involved in VWR

1.2.1 The Frequency Effect

The frequency effect is a hallmark of VWR studies due to its early discovery in 1950s and it has been a crucial variable in theoretical developments. Insofar as accuracy and reaction times are concerned high frequency (HF) words have a significant advantage over low frequency (LF) words. For example, in Balota et al.'s (2004) mega study where researchers have tried to underline significant factors that affect reading in English, word frequency was among the most impactful significant variables, though only single-syllable words were included. One might think that such a significant variable should be easily integrated into models. On the contrary, almost all VWR models found a different way to account for the frequency effect (thresholds in Coltheart et al., 2001; weights of connections in Seidenberg & McClelland, 1989, and frequency dependent search bins in Murray & Forster, 2004). Some researchers contemplated that task-specific operations might have a role in the frequency effect as well. For instance, in lexical decision task (LTD) similarity between LF and non-words (NWs) are higher than between LF and HF words, especially for opaque orthographies; which in turn makes it hard to perceive identify LF words as real words. Nonetheless, the frequency effect has been a crucial part of the theoretical developments in the VWR studies, and to this day it still holds its importance.

1.2.2 Age of Acquisition

Rochford and Williams (1962a, 1962b) were the pioneers who did the first exploration on AoA (i.e., early acquired concepts have an advantage over late acquired concepts). Since then, to reveal AoA's role in language processes such as processing of words, pictures, phrases, faces and even processing non-linguistic stimuli, many researchers have conducted experiments on this effect (e.g, Anderson, 2008; Arnon et al., 2017; Bonin et al., 2008; Lima et al., 2021; Marful et al., 2018; Mayberry et al., 2011; Sereno & O'Donnell, 2009; Smith-Spark et al., 2012, 2013). The results of these studies have reached a consensus on the fact that early-acquired items have higher processing speed, higher accuracy counts, and are less prone to interference, brain damage, and forgetting than late-acquired acquired (For a recent review, see Elsherif et al., 2023). Some researchers such as Steyvers and Tennenbaum (2005) have argued that early acquired words might have a crucial effect on the initial mental representations such that building the rest of the mental lexicon relies on these early acquired words. Furthermore, although not all early acquired words are HF words, it is certain that early acquired words have a higher chance of exposure across the lifetime.

There are several theoretical accounts of AoA, such as the multiple loci account (Catling & Johnston, 2006a, 2006b, 2006c; Moore et al., 2004; Räling et al., 2016), the mapping theory (Anderson & Cottrell, 2001; Ellis & Lambon-Ralph, 2000; Hirsh & Funnell, 1995; Monaghan & Ellis, 2010) and representation theory (Brysbaert & Ghyselinck, 2006). As its name suggest the multiple loci account (Catling & Johnston, 2006a, 2006b, 2006c) proposes that AoA effect resides in more than one language related component (e.g., phonology and orthography) relying on several studies where AoA effects could not be explained with only one language domain (at least perceptual and phonological representations involve AoA within, Moore et al., 2004; Moore & Valentine, 1998; Smith-Spark et al., 2013). On the other hand, representation theory (Brysbaert & Ghyselinck, 2006) posits that AoA effects are heavily frequency dependent due to similar type and size of effects observed in semantic categorization task and LDT. Also, this theory suggests that frequency independent AoA effects are also evident, and these effects happen due to competition of representations within the conceptual/semantic system. In this system early acquired words have a stronger inhibition power during representations' competition because simply compared to late acquired words, early acquired words have more semantically related connections and more connections with other words as well. Lastly, the mapping theory (Monaghan & Ellis, 2002) which is strongly influenced by PDP models (Seidenberg &McClelland, 1989) suggests that contrary to above-mentioned accounts, AoA doesn't reside within the language related systems. Instead, it stems from connections between these systems (e.g., between semantic-orthography) and is a product of a learning system. Moreover, Monaghan and Ellis (2002) discussed that in opaque languages where the mappings between phonology and orthography are arbitrary there is a higher chance of obtaining AoA effects due to significant differences between regular and irregular word spellings. Zevin and Seidenberg (2002) took a step further and claimed that in transparent orthographies where regular the mappings between phonology and orthography are regular, AoA effects stem solely from cumulative frequency effects.

1.2.3 Word Length Effect

Word length effect is recognized as an important factor to inform VWR theories which is the effect of number of letters in a word on RTs (Coltheart et al., 2001). For instance, Weekes' (1997) results showed that length had no significant effect on words but systematically influenced NW latencies. Moreover, Balota et al. (2004) reported that compared to HF words length effect was more pronounced for LF words. Even though Weekes did not find an effect of length for words, the pattern between both Balota et al. (2004) and Weekes' findings resemble each other. Relatedly, Gold et al. (2005) found that regular consistent words amplified length effects obtained from participants with semantic dementia as opposed to healthy controls. These findings are crucial for two reasons. First, the Parallel Distributed Processing (PDP) models (Seidenberg & McClelland, 1989) has failed to explain the length by lexicality interaction reported by Weekes whereas the Dual Route Cascaded (DRC, Coltheart et al., 2021) model anticipates a significant effect. As previously mentioned, in the DRC model the sub-lexical pathway is a serial processor (primarily involved in NW processing), whereas the lexical pathway is a parallel processor (primarily involved in word processing). Thus, larger length effects should be observed from people with semantic dementia who primarily uses the sub-lexical pathway to read, due to experienced impairment within the lexical pathway. Contrary to the DRC model, both words and NWs processed through the same parallel structure in the PDP model. As the key variables in VWR are discussed, theoretical considerations will be discussed in detail within the next section.

1.3 Theoretical Considerations

The following will be a historical summary of frameworks, models and theories on VWR. The earliest models that were trying to illuminate the processes involved in VWR can be separated into two different types which are activation models (Morton, 1969) and search models (Forster, 1976) respectively. To get a grasp of these models, word frequency effect needs an introduction. Compared to low frequency words, high frequency words have shorter RTs and higher accuracy rates across plenty of tasks. Due to powerful and consistent effects observed from studies, earlier models (e.g., search and activation models) have used word frequency effect as a building block (Murray & Forster, 2004). To give an example, according to Morton's logogen model (1969), within the mental lexicon words are represented as logogens which resembles dictionary units.

These logogens' activation levels are open to change in line with frequency; as the cognitive system gets exposed to a particular word, its activation threshold decreases. To put it simply, words that have frequent exposure (HF words) need less processing time (in turn, gets activated faster) compared LF words. Moreover, search models (Forster, 1976; Rubenstein et al., 1970) are another class of models where the mental lexicon's structure is dependent on frequency and representations are activated in a serial fashion. Instead of logogens in Morton's model (1969), these models have described orthographic bins as mental representations which are located in the mental lexicon according to their frequency measures. In other words, if the mental lexicon can be considered a straight line where words are stored, HF words would be at the front, easy to reach and LF words would be at the back of the line, harder to reach.

Apart from these, hybrid models were also proposed (e.g., Becker, 1979; Taft & Hambly, 1986) which are combinations of the above-mentioned models. To exemplify hybrid models, Becker (1979) suggested an initial stage similar to Morton where semantic and sensory sets becomes activated. Upon their activation, similar to the search models, these sets are compared with the target stimuli in a serial manner. Furthermore, connectionist models are another important class of models which are still influential in theoretical discussion on VWR. The interactive activation (IA) models introduced by McClelland and Rumelhart. (1981) are the pioneers of connectionist models (also see, Rumelhart & McClelland, 1982; Paap et al., 1982). IA models integrated some aspects of Morton's model and were heavily influenced by Selfridge's (1988) pandemonium model of letter recognition. In pandemonium model a hierarchical communication line was proposed. The initial search was on letters based on their visual aspects, then this information is passed on to another level where letter-level representations are stored.

Finally, a decision component communicates with letter-level representations for a final outcome. Selfridge's (1988) model was influential because it was one of the earliest computational models of pattern recognition.

Relatedly, McClelland and Rumelhart's IA model (1981) was made up of several components, which are feature detectors, letter detectors, and word detectors. Feature detectors focus on letter positions, letter detectors are responsible from identifying letters, and word detectors combine all information to identify a word. These different components are connected by excitatory and/or inhibitory pathways. For example, during letter string processing, word-level representations get activated by letter-level representations through facilitatory signals. At the same time, the word level representations facilitate letter-level representations in a top-down process and inhibitory communications happen between competing representations which aids the activation of an appropriate response. For example, seeing the word 'heal' activates its word-level representation, as a consequence, other competing words such as 'deal' and 'seal' receive inhibitory signals by the word-level representations of 'heal'.

Despite its importance and influence, the focus of the original IA model was letter recognition performance, in turn it was limited in its explanatory power regarding VWR. Hence, to capture word recognition performance some of the following models extended the IA model (McClelland and Rumelhart, 1981). For instance, the dual-route cascaded (DRC) model (Coltheart et al., 2001) has a similar component that resembles the IA model. The next three paragraphs will focus on recent computational models on VWR, starting from DRC model.

Investigations on cognitive processes that underline skilled reading have used several computational models. These models offer a mechanistic description of cognitive phenomena of interest and provide an opportunity to test specific predictions explicitly (Forstmann et al., 2011). The dual-route cascaded model of visual word recognition and reading aloud (DRC) (Coltheart et al., 2001) is an influential model which is formed to imitate a skilled reader's cognitive mechanisms. The model is based on the dual-route theory of reading aloud (Forster & Chambers, 1973; Marshall & Newcombe, 1973) which suggests two distinct pathways, namely lexical and sub-lexical pathways that are associated with reading aloud. Known regular and irregular words can be processed via lexical pathway by identifying whole written words automatically, whereas NWs and novel regular words can be processed via sub-lexical pathway by conversing constituent letters of a word into a phonologic representation in a serial manner (Coltheart, 2006). Additionally, the DRC model has provided successful simulations for a multitude of word reading effects in skilled readers in several languages other than English (Coltheart et al., 2001), which have alphabetic orthographies such as French (Ziegler et al., 2003), Greek (Kapnoula et al., 2017), Italian (Scmalz et al., 2015) and Russian (Ulicheva et al., 2016).

Another important model family is PDP models which try to simulate cognitive processes by utilizing a method inspired by neural networks. These models differ from the DRC model specifically due to the absence of a mental lexicon (Plaut, 1997; Seidenberg & McClelland, 1989, 1990). Instead, these triangle models (Harm & Seidenberg, 1999, 2004; Plaut, McClelland, Seidenberg, & Patterson, 1996; Seidenberg & McClelland, 1989) have built on units of orthographic, phonological and semantic via a set of statistical representations. Though early versions of PDP models (Seidenberg & McClelland, 1989) have shown significantly worse performance in the naming task (NT) compared to skilled readers in English (Besner et al., 1990), Plaut et al. (1996) have successfully created a model that can simulate adult readers' performance in NTs and a wide array of other phenomena related with reading aloud. Moreover, Harm and Seidenberg's (2004) inclusion of the semantic pathway has provided an almost complete network. After this, PDP models too have adapted to different orthographies such as Chinese (Yang et al., 2009), German (Hutzler et al., 2004), Italian (Paglucia & Monahan, 2009) and Japanese (Ikeda et al., 2016).

Lastly, The CDP family of models (CDP: Zorzi et al., 1998; CDP+: Perry et al., 2007; CDP++: Perry et al., 2010; CDP++.parser: Perry et al., 2013) stand at the middle of the two abovementioned models where they utilize a parallel distributed processing structure like PDP models while using the dual-route approach (Zorzi, 2010). The lexical route of CDP models is superior to the DRC model where there are more words in the lexicon including multi-syllabic words (Perry et al., 2010). What separates the lexical route of the CDP models is that it has higher vocabulary count than the DRC model and multi-syllabic words also added to latest versions (CDP++: Perry et al., 2010). Moreover, with regards to sub-lexical route, compared to DRC model which uses a list of distinct rules to transform graphemes to phonemes, the CDP models use a connectionist, two-layer associative (TLA) network via the identification of statistical associations between phonological and orthographic word parts.

To sum it up, there are plentiful theoretical frameworks which try to explain VWR processes. Now that the key theories and issues have been considered, next paragraph will explore the procedures that have been used in VWR briefly.

1.4 Tools Used in VWR Research

Historically VWR researchers have used a variety of different procedures to examine the underlying processes associated with it. Some studies included procedures that intentionally degrade participants' vision briefly or throughout the procedure where they were asked to identify words (i.e., perceptual identification, Broadbent, 1967). Other studies used eye-tracking techniques to examine participants' eye movements (e.g., duration measures, fixation points) while they were presented with words (Schilling et al., 1998). Moreover, researchers also used semantic categorization task (Taft & van Graan, 1998) in which participants were asked to categorize the words they were presented with (e.g., is blue a colour?). Furthermore, impactful findings about typical reading were obtained by studying people with language impairments such as dyslexia (Haywood & Coltheart, 2001). These tasks have provided meaningful insights to the VWR studies but all of them have some drawbacks (see Balota et al., 2004)

Due to abovementioned tasks having some costs that might diminish findings' value, LDT and NT have become most VWR researchers' primary method. The LDT task required participants to respond as quickly and accurately as possible to where they were asked to decide whether a presented word is a real word (e.g., cat) or a NW by pressing a key (e.g., crulk). In the NT, again participants were presented with an isolated word (words and NWs) and they were instructed to read aloud that word as quickly and accurately as possible. In both tasks researchers measure RTs and accuracy where they experimentally manipulate different variables to assess their effects on reading processes. RTs were interpreted as the time it takes to activate a word within the mental lexicon (Jared & Seidenberg, 1990). Accuracy rates have been consistent within a language but it might vary between languages, and it is an indication of a language's transparency (i.e., regularity of letter to sound correspondences, e.g., Turkish has almost one-to-one mappings between its letters and sounds and considered a highly transparent language).

After reviewing the tasks used in VWR, the following section explores the impact of orthography on language as well as universal and specific aspects of language.

1.5 Specific-Universal Features of Language and the Role of Orthography

Orthography can be defined as the associations between a language's script and the language itself (Aloufi, 2021). A given language's print-to-sound mappings (i.e. an orthography's mapping onto its phonology, also called grapheme-phoneme-correspondence (GPC) are claimed to affect both skilled and learner readers' language processing. This topic has attracted many researchers over the past 40 years, and a multitude of studies investigated the language-specific and universal processes in different languages. In this regard, the Orthographic Depth Hypothesis (ODH, Frost et al., 1987; Katz & Feldman, 1983; Katz & Frost, 1992) has been an influential postulate for the field which claims GPC of a language is the decisive factor of its orthographic transparency in alphabetic scripts and accordingly, it affects reading strategies of readers. According to ODH, if GPCs are consistent for a particular language, it is defined as a transparent or shallow orthography, and readers of transparent orthographies utilize a print-to-sound strategy in which they decode the constituent letters in a sequential manner. In contrast, in opaque or deep orthographies, readers adopt a lexical strategy where they process the words as a whole. What this suggests is that if a word is phonologically transparent, priming and word frequency effects should be null for that word as these require lexical processing to show their effects.

However, results from a plethora of studies that focused on transparent languages showed priming and/or word frequency effects (e.g., Crotian (Carello et al., 1988), Japanese (Wydell, 1991), Italian (Burani et al., 2007), Persian (Baluch & Besner, 1991), Spanish (Sebastián-Gallés, 1991), and Turkish (Raman, Baluch & Besner, 1996), and cumulative results from these studies have established a strong criticism to ODH. Other researchers have tried to propose a universal hypothesis to answer ODH, such as the Universal Mediation Hypothesis by Frost (1998) in which it is postulated that phonology has a crucial pre-lexical role in reading.

Moreover, some researchers have proposed two-dimensional approaches for orthographies. The Hypothesis of Granularity and Transparency (HGT) by Wydell and Butterworth (1999) has defined transparency and granularity as the two dimensions. HGT postulates that phonological dyslexia occurrences should be lower for transparent languages. Additionally, the same postulate has been argued for orthographies that have coarse representing sounds as the largest grain size (i.e., a whole word or a whole character). Relatedly, Psycholinguistic Grain Size Theory (PGST) (Ziegler & Goswami, 2005) agrees with the latter postulate which is the role of grain size in phonological dyslexia incidents whereas does not agree with the former postulate regarding the linear relationship between orthography's transparency and diminished phonological dyslexia incidents. As language-specific aspects are discussed, the next paragraph will move on to universal features of reading.

Language Constraint on Writing Systems (Perfetti & Liu, 2005) is widely recognized as a fundamental universal aspect which suggests that writing systems are shaped by the structure and aspects of their respective languages and printed words are not isolated symbols that carry any meaning by themselves, instead, readers could recognize the printed words within the context of a particular language. Likewise, the Universal Phonological Principle (UPP) (Perfetti et al., 1992; Perfetti & Harris, 2013) suggest that regardless of any orthography, phonology is activated as early as the given writing system permits its activation. Nonetheless, there are plenty of research questions or mixed results to deal with before having a clear understanding of specific and universal aspects of reading (Venezky, 2006). Another issue is that most of the studies and theories on reading have strong Anglo-centric and/or Eurocentric influences (Share, 2008). Consequently, these theories cannot be generalized to all readers around the world since their applicability to non-European/ English orthographies remains questionable. Hence, it is important to broaden reading research in terms of diversity and results from other orthographies should be considered to understand how well these theories account for reading in languages that are transparent. The following section will describe a non-English/European orthography, namely Turkish, which has a huge potential to provide unique findings to reading theories because its extreme transparency and highly agglutinative nature.

1.6 Characteristics of Turkish Orthography

In this section characteristics of the Turkish language will be discussed. Turkish is an extremely transparent orthography, so far, the most transparent orthography that has been quantified (Raman, E., 2021), which has almost one-to-one mappings between its phonology and orthography (Raman, 2006, 2011).

In Turkish the standard word order is subject-object-verb (SOV) and the Turkish alphabet consists of 21 consonants and 8 vowels and contains 32 graphemes and 29 letters (Türk Dil Kurumu (TDK) Yazım Kılavuzu, 2013). Regardless of its extreme transparency, several studies have demonstrated lexicality effects in Turkish (Raman, Baluch & Besner, 1996, 2004; Raman & Baluch, 2001). Nonetheless, there are a few ambiguities in grapheme-phoneme conversion such as the existence of homographic compound and loan words (majority of them from Arabic and Persian) as well as special cases of morpho-phonology (e.g., vowel length alternations) (Göksel & Kerslake, 2004; Külekçi & Oflazer, 2006).

Additionally, Turkish is an agglutinative language like Finnish (Niemi et al., 1994), Hungarian (Gervain, 2022), and Korean (Kim et al., 2021), which has a rich morphological complexity (i.e., words with high number of suffixes to the root) and because of this feature words in Turkish have relatively longer lengths. For example, the translation of the following English sentence "I may not be able to explain" (The sentence includes 7 words) into Turkish is "Anlatamayabilirim", a relatively long word which consists of multiple morphemes (an-la-t-a-ma-ya-bil-ir-im). Following this brief introduction to Turkish language, VWR studies conducted on Turkish will be explored in the consequent section.

1.7 VWR and AoA Research Findings on Turkish

To date, there have been a few psycholinguistics studies conducted on VWR with skilled Turkish readers. As part of their doctoral research, Öney (1990) investigated the context effect on word recognition using LDT and NT. The results showed that compared to inconsistent context words, contextual words provided faster RTs. Öney suggested that overall results imply a heavy use of sublexical route for Turkish readers. Conversely, Raman (1999) objected to this idea in her doctoral thesis and argued that significant semantic priming effects found in the NT point out to the use of the lexical route (i.e., retrieving words from mental lexicon). Furthermore, word frequency effects found in a NT with Turkish skilled readers suggests that the lexical route is used even in transparent orthographies (Raman et al., 1996; Raman & Baluch, 2001). On top of these, Raman, Baluch and Besner (2004) investigated route preferences in Turkish readers, and offered a parallel processing model for word naming in Turkish in which both lexical and non-lexical routes process the words interactively and simultaneously meaning, this means that known words can be processed by using both routes. Moreover, in his doctoral thesis, Bilgin (2016) compared RTs for nouns with HF affixes vs. LF affixes in an LDT and found significantly faster RTs for HF affix condition which shows that in an agglutinative language where long words and long suffixes are common, frequency effects are evident even for affixes. Finally, in his doctoral research, Raman, E. (2021) utilized an LDT to validate SUBTLEX-TR frequency measures and found significant length, lexicality, and neighbouring size effects when both NWs and words are taken into consideration as well as frequency, contextual diversity, length, and neighbourhood size effects when only words were considered.

As for work on AoA effects in Turkish, there has been several experiments that have found reliable and significant effects which used NT (Raman, 2006; 2011; Raman, Raman, E., et al., 2014) and two studies used the free recall method to investigate AoA effects in Turkish (Kilecioğlu et al., 2022; Raman, Raman, E., İkier, et al., 2018;) and findings revealed an advantage for early AoA words which suggest that AoA effects are not only found in irregular orthographies and are not dependent on the arbitrary mappings.

Moreover, Raman (2011) explored the differential effects of AoA in picture and word NTs by comparing dyslexic adults with non-dyslexic adults in Turkish and results showed significantly slower RTs for the dyslexic group compared to the non-dyslexic group in both tasks but there was no significant difference for accuracy rates and performance of both groups were quite good. High accuracy rates for the dyslexic group interpreted as accuracy rates should not be taken as valid predictors of developmental dyslexia in transparent orthographies. To conclude, limited studies available on skilled reading in Turkish showed promising results to inform reading theories and further inquiries about other significant variables such as letter length, concreteness, etc.

1.8 The Rationale for the Current Study

Many studies on letter length have clearly shown significant impacts on reaction times (RTs) where participants took longer to respond to longer words and NWs (e.g., Balota & Chumbley, 1984; Forster & Chambers, 1973; Frederiksen & Kroll, 1976; Jared et al., 1990; Yap & Balota, 2009). In one of the prominent studies, employing a naming task Weekes (1997) have shown that the number of letters impact RTs in English. On top of that, preliminary research on Turkish (Kökten & Raman, 2007) investigated this length effect and the results provided only partial support for Weekes' findings where length effect was present for both high and LF words. The discrepancy between the two languages might be explained by orthographic transparency differences (i.e., the ease or difficulty with which one can translate letters to phonemes). Hence, orthographic transparency might strongly affect the other lexical variables like word frequency where length is considered. Further, as mentioned above, previous research on Turkish has shown that although it is an extremely transparent language, Turkish readers can use a lexical strategy while reading (Raman et al., 2004) and several studies highlight robust frequency effects in Turkish (Raman et al., 1996; Raman & Baluch, 2001; Raman, E., 2021). These results have been interpreted within Coltheart et al. (2001)'s DRC where all previously known words in Turkish are processed via a lexical route, whereas new words and NWs are processed via a non-lexical route. Within the dual-route model framework, it is widely assumed that length effect is related to non-lexical processing in which words are processed according to GPCs.

The abovementioned study by Weekes' (1997) explored the possible differential effects of word length effect on RTs in a naming task. Twenty undergraduate students were recruited to take part in both experiments. Experimental stimuli included HF words, LF words and NWs comprised of 3, 4, 5 or 6 letters. The results of Experiment 1 showed a significant length effect for LF words and NWs whereas there was no significant effect for HF words. This means that number of letters in a word is only associated with LF words and NWs but not with HF words. As the number of letters increase in LF words and NWs, so does naming latencies but this same trend was not present word HF words which suggests the use of lexical route. Further, in Experiment 2 a delayed naming task was employed to make sure that the differential effects of number of letters on RTs are indeed related to time taken to create a phonological response. The results of Experiment 2 showed no significant effects of letter length on RTs for NWs and LF and HF words and provided support that in the first experiment the RTs are affected by the time taken to provide a phonological response.

In light of these findings, Weekes (1997) suggested that the consistent significant influence of length effect for NWs could be attributed to using a non-lexical pathway (by using print to sound rules while reading) during NW reading; on the contrary, number of letters' effect on RTs during word reading should have a lesser influence since generation of the words are processed via a lexical pathway (by retrieving the word from the mental lexicon). Due to parallel reading mechanisms involvement in the lexical pathway, it is strongly affected by frequency. Kökten and Raman (2007) have conducted a similar study design in Turkish to partially replicate Weekes's (1997) study and provide a different perspective in discussion. The researchers were interested to explore length effects for a language that almost 100 percent transparent in its orthography (i.e., orthography to phonology mappings are completely consistent with no exception). The findings revealed that there was a significant length effect for both LF and NWs and for HF words, contrary to the findings in English. The regression analyses revealed that compared to frequency, lexical status of the letter string was better when predicting naming RTs although there was a significant difference between HF and LF words. The authors noted that each additional letter corresponded to approximately 30 milliseconds of delays during naming task for Turkish words regardless of lexical status of the letter string the frequency of the word.

Taking all of the information into account, the current study's aim is to extend Kökten and Raman's (2007) investigation by examining whether RTs would be influenced by the age in which words enter into our vocabulary, AoA; more specifically, to investigate a) whether and b) the extent to which AoA affects RTs in a LDT where words' letter length is critically manipulated. The rationale is driven by reports that the reliable advantage for early acquired over late acquired words across a range of lexical tasks is taken as an indication that AoA mimics word frequency (see Elsherif, 2023 for a review; Raman, 2006) and shorter RTs were expected for early acquired words compared to late acquired words. The study has the potential to address some of the theoretical issues raised in this respect. To the author’s knowledge, regarding VWR no past study has examined the interaction between AoA and word length in the Turkish language. Additionally, subjective AoA ratings from participants will be obtained to validate Raman, Raman, E., & Mertan (2014) AoA norms. If AoA indeed mimics frequency effects then it is predicted that as Kökten and Raman (2007) reported for frequency, length effect would significantly influence early acquired and late acquired words, as well as NWs. However, if AoA does not mimic frequency effects then it is predicted that the findings will mimic Weekes’ (1997) results where only late acquired words and NWs would be significantly influenced by length effect but not early acquired words.

Chapter 2

METHOD

2.1 Design

The current study has employed a 3 (Type of Stimuli: Early AoA words, Late AoA words, NWs) x 5 (Number of letters in a word: three, four, five, six and seven) repeated measures design by using a lexical decision task (LDT). For this experiment, dependent variables were response accuracy and RTs. Moreover, independent variables were lexicality (word vs. NW), AoA (early vs. late) and word length (3, 4, 5, 6, and 7 seven letters) In the LDT, RTs were measured in milliseconds (ms) and defined as the amount of time passed between the very moment of a word's presentation and the time participant pressed to the button.

2.2 Participants

The current study used Linear Mixed Model (LMM) analysis and classical sample size estimations (e.g., using G*Power, Faul et al., 2007) are not applicable to LMM analysis. Therefore, Brysbaert and Stevens's (2018) effect size recommendations for mixed effects models have been taken into account. To capture significant RT differences with 80% power and d = .25 as little as 20 ms recommended observations per condition is 1600. Considering that the current study has 15 different conditions, and 160 stimuli, recruiting 150 participants was enough to detect significant differences between conditions ((1600x15) / 160 = 150). Participants recruited through several ways including announcements on both social media channels, and Eastern Mediterranean University (EMU, North Cyprus) Psychology Department's participant pool and flyers across EMU campus. In total, 151 people (mostly students from EMU) participated in the study. All participants were native Turkish speaking adults above the age of 18 years who had normal or corrected to normal vision and no speech or hearing impairments and no learning difficulties.

A total of seven participants took part in the pilot versions of the experiment to ensure the experiment was working properly. According to their feedback minor changes were made to instruction texts. Due do these changes their data were not included in the final analysis. Also, 1 participant had technical issues during the LDT and their data was removed from the final analyses. Ten participants did not indicate their age (M_{age} = 27.2, *SD* = 7.33), and two participants did not indicate their gender (76 female, 70 male, 2 prefer not to say) (see Table 1 for participants' demographics and subjective Turkish proficiency scores).

Table 1**:** Descriptive of Participants' Demographics and Subjective Turkish Proficiency Scores

	Age	**Speaking**	**Understanding**	**Reading**	**Overall**
Mean	27.2	9.13	9.32	9.27	9.24
Median	26.0	10.0	10.0	10.0	10.0
SD	7.33	1.24	1.06	1.11	1.06
Minimum	18	5	4	5	6.00
Maximum	56	10	10	10	10.0

2.3 Materials

Experimental Stimuli**:** Words used as the experimental stimuli were derived from Raman, Raman, E., and Mertan (2014)'s Turkish word norms. In total, 40 early acquired words were divided into five different length conditions equally (8 early AoA for each length condition): three letter early AoA words (e.g., göz/EYE), four letter early AoA words (e.g., kedi/CAT,), five letter early AoA words (e.g., bebek/BABY), six letter early AoA words (e.g., gözlük/EYEGLASSES), seven letter early AoA words (e.g., karınca/ANT). Further, a total of 40 late acquired words also were divided into five different length conditions equally (8 late AoA for each length condition): three letter late AoA words (e.g., ütü/IRON), four letter late AoA words (e.g., çapa/HOE), five letter late AoA words (e.g., paten/SKATE), six letter late AoA words (e.g., çıkrık/SPINNING WHEEL), seven letter late AoA words (e.g., kereviz/CELERY). Finally, 80 NWs have been created by using UniPseudo (http://unipseudo.lexique.org, New et al., 2024) which is an online word generator tool that creates NWs based on the uploaded stimuli set. Here, NWs were again divided into five different length conditions equally: three letter NWs (e.g., taz), four letter NWs (e.g., kapu), five letter NWs (e.g., patek), six letter NWs (e.g., zincan), seven letter NWs (e.g., merdani). (See Appendix A for stimuli used in practice and experimental trials and their mean AoA values)

LEAP-Q (Language Experience and Proficiency Questionnaire, Marian et al., 2007)**:** A mini-version of Turkish LEAP-Q was used to collect demographic and language related information. Participants were asked a few demographic questions (age and gender) and about their speaking, reading, and comprehension skills in Turkish out of 1 to 10. Participants were also asked to indicate if they have any visual, speech or hearing impairment, and if they have any learning difficulties.

Lexical Decision Task (LDT): In the LDT, participants were presented with either a word or a non-word on the computer screen and they were asked to decide whether the word was a real word or not. Two dedicated keyboard buttons were allocated as YES (the letter “a”) and NO (the letter “l”) responses and participants were asked to press to the button that indicated their decision. Participants were instructed to adjust the keyboard closer or farther to them according to their preference during the experiment. Moreover, participants were instructed to use any two fingers they feel they are comfortable with to press the allocated keys throughout the experiment. Presented words have been shown in a randomized order and each participant completed a different set of word order. In the beginning, 10 practice trials were presented to make participants familiar with the experiment. After that 160 words were presented in 4 blocks to the participants (40 words in each block). Between each blocks, participants were informed that they might take a break if they wish to do so. Finally, participants were instructed to respond as fast and as accurate as possible without any breaks within the blocks. However, they were also reminded that it is normal to make mistakes when one tries to respond as fast as possible and participants were asked to remain calm and keep responding as fast as possible in such cases.

2.4 Procedure

Ethical approval was obtained from EMU’s Social, Humanities and Administrative Sciences Ethics Subcommittee (Ref No: ETK00-2025-0002) prior to the study (See Appendix B for ethics document). All data collection procedures took place at

EMU's Cognitive Psychology Labs. Each participant was briefed orally regarding the experiment by the experimenter and kindly invited to sit in front of the computer to read the information sheet and give their informed consent. The experiment was built on the Gorilla Experiment Builder (https://www.gorilla.sc) and participants used this platform to complete the experiment. Upon obtaining their consents, participants completed a mini version of the LEAP-Q

Subsequently, participants received instructions for the LDT task. After finishing the LDT, to validate the norms that were used in the Raman et al., 2014), participants were asked to provide an estimated age at which they thought that they had acquired each real word that was presented to them in the experiment. The current study did not employ a scale approach as Raman et al. (2014)'s study. Forcing participants to choose within a scale reported to be a restricted factor during the estimation of a word's AoA (Kuperman et al., 2012) and it is claimed that participants find it easier to type the age instead of choosing between options. For this validation process, the presentation order of the words was randomized across participants. Upon completing this task, participants were debriefed and thanked for their participation. Participants recruited via participant pool received 0.5 course credit for their participation.

Chapter 3

RESULTS

3.1 Data Reduction

Historically psycholinguistic researchers and many cognitive psychologists have been analysing mean RT data using ANOVA tests to explain the difference between conditions or variables of interest. However, this approach raises several problems such as RTs usually being positively skewed in simple tasks like LDT (Lo & Andrews, 2015) and their inability to explain the variances caused by random effects such as individual differences of participants or variance caused by item differences. Also, this raises questions against the validity of the theories because as previously mentioned most theories rely on these mean RTs (Speelman & McGann, 2013). However, in the last 15-20 years there has been a trend towards using better statistical analyses (Balota & Yap, 2011) including LMMs. LMMs have the capacity to tackle the above-mentioned issues by both taking random effects into account and not relying solely on mean RTs. Hence, LMMs have become a powerful recommended analysis for psycholinguistics researchers (Baayen et al., 2008) and the current study's RT data were analysed using this statistical approach.

During the data reduction process, previously reported studies addressing similar research questions were taken into consideration to establish the bases for comparable technique and parameters (Balota & Yap, 2011; Balota et al., 2012; Brysbaert & Biemiller

2016; Ferrand et al., 2010; Keuleers et al., 2012). Based on this literature, it was decided to use the relative cut-off approach for accuracy and the cut-off set as 70% of correct answers. It should be noted that no participant had below 70% accuracy ($M_{TotalAccuracy}$ = .95, *SD* = .21) in the present study. Accordingly, from a total 25500 responses, false responses (1639 responses) and responses lower than 250 ms and higher than 3000ms (1125 responses) were not included in the final analyses (see Table 2 for the descriptives of accuracy by word type and letter length). The remaining 22736 responses were entered into the final LMM analyses. All data analyses were conducted using Jamovi version 2.3.28.

3.2 Data Analyses

Data were subsequently analysed using descriptive and inferential statistics as reported below:

Table 2: Descriptives – LDT Accuracy by Word Type

	Word Type	**N**	**Missing**	***M***	**Median**	***SD***
Correct	3E	1193	0	0.98	1	0.13
	3L	1197	0	0.95	1	0.21
	4E	1195	0	0.98	1	0.15
	4L	1196	0	0.92	1	0.27
	5E	1194	0	0.98	1	0.15
	5L	1199	0	0.87	1	0.34
	6E	1195	0	0.98	1	0.14
	6L	1192	0	0.92	1	0.27
	7E	1193	0	0.99	1	0.11
	7L	1194	0	0.96	1	0.19
	Words	11948	0	0.95	1	0.21

NWs	11913	0	0.95	1	0.21

Abbreviations: 3E, three letter early words; 3L, three letter late words; same logic applies to all other word types except NWs.

3.2.1 LDT Accuracy-Lexicality x Length

Due to accuracy data being binary, generalized mixed models (GLMM) were used in this analysis. To start with, "lme4:glmer" package was used as the model. The model type was selected as Logistic, distribution was selected as binomial and the link function was selected as Logit (see Appendix C, C1 for more information on model info). Regarding the degrees of freedom, Satterhwaite approximation was used. Fixed factors included in the model were lexicality, length and their interactions. Random factors included were participants and items. Model fit was tested using a likelihood-ratio test which showed that when taking both fixed and random effects, the model provided better fit for the data compared to no model, $\chi 2(11) = 1058.87$, $p < .001$, explaining 30% of the variance. However, when only fixed effects were taken into consideration, the model showed no significance, $\chi 2(9) = 14.05$, $p > .05$, and the explained variance decreased to 2% (see Table 3).

Table 3: Likelihood-Ratio Test for LDT Accuracy - Lexicality x Length

Type	R^2	*df*	**LRT** $\chi 2$	*p*
Conditional	0.30	11	1058.87	< .001
Marginal	0.02	9	14.05	0.120

The fixed effect omnibus test (see Table 4) showed a significant main effect for Lexicality, $\chi 2(1) = 5.49$, p = .019, but not for Length, $\chi 2(4) = 1.68$, $p = .795$, and neither for Length x Lexicality interaction, $\chi 2(4) = 7.90$, $p = .095$.

Table 4: Fixed Effects Omnibus Test LDT Accuracy- Lexicality x Length

Names	$\chi 2$	*df*	*p*
Lexicality	5.49	1.00	0.019
Length	1.68	4.00	0.795
Lexicality * Length	7.90	4.00	0.095

Moreover, parameter estimates for fixed coefficients (see Appendix C, Table C5) showed that actual words were more likely to receive accurate responses than NWs, $\beta = 0.37$, *SE* = 0.16, $z = 2.34$, $p = .019$. Additionally, Post-Hoc comparisons using Bonferroni correction showed that the odds of correct responses for NWs were 31% less than actual words (*OR* = .69) (see Table 5).

Table 5: Post Hoc Comparison for Lexicality – LDT Accuracy

Comparison						
Lexicality	**vs**	**Lexicality**	**OR**	**SE**	*z*	$p_{bonferroni}$
NW	-	word	0.69	0.11	-2.34	0.019

3.2.2 LDT Accuracy-Length x AoA

Same model choices were made here as in LDT Accuracy - Length x Lexicality reported above (see Appendix C, Table C2). Here, fixed factors included in the model were Length, AoA and their interactions. Random factors included were participants and items. Model fit was tested using a likelihood-ratio test which showed that when taking both fixed and random effects, the model provided better fit for the data compared to no model, $\chi 2(11) = 831.33$, $p < .001$, explaining 38% of the variance. Moreover, when only fixed effects were taken into consideration, the model still showed significance, $\chi 2(9) = 32.02$, $p < .001$, and the explained variance decreased to 11%. This means that random effects were responsible from 27% of the variance (See Table 6).

Table 6: Likelihood-Ratio Test for LDT Accuracy - Length x AoA

Type	R^2	*df*	**LRT** $\chi 2$	*p*
Conditional	0.38	11	831.33	< .001
Marginal	0.11	9	32.02	< .001

The fixed effect omnibus test (see Table 7) showed a significant main effect for AoA, $\chi 2(1) = 30.26$, $p < .001$, but not for Length, $\chi 2(4) = 5.11$, $p = .276$, and neither for Length x AoA interaction, $\chi 2(4) = 2.15$, $p = .708$.

Table 7: Fixed Effects Omnibus Test LDT Accuracy - Length x AoA

Names	***χ2***	***df***	***p***
Length	5.11	4.00	0.276
AoA	30.26	1.00	< .001
Length * AoA	2.15	4.00	0.708

Further, parameter estimates for fixed coefficients (see Appendix C, Table C6) showed that early AoA words were more likely to receive accurate responses than late AoA words, $\beta = 1.35$, $SE = 0.25$, $z = 5.50$, $p < .001$. Additionally, Post-Hoc comparisons using Bonferroni correction showed that the odds of correct responses for early Ao A words were 2.86 times greater compared to late AoA words (*OR* = 3.86) (see Table 8). Also see Figure 1 for a comparison between early and late AoA words regarding accuracy.

Table 8: Post Hoc Comparisons for AoA - LDT Accuracy - Length x AoA

Comparison						
AoA	**vs**	**AoA**	***OR***	***SE***	***z***	$p_{bonferroni}$
Early	-	Late	3.86	0.95	5.50	< .001

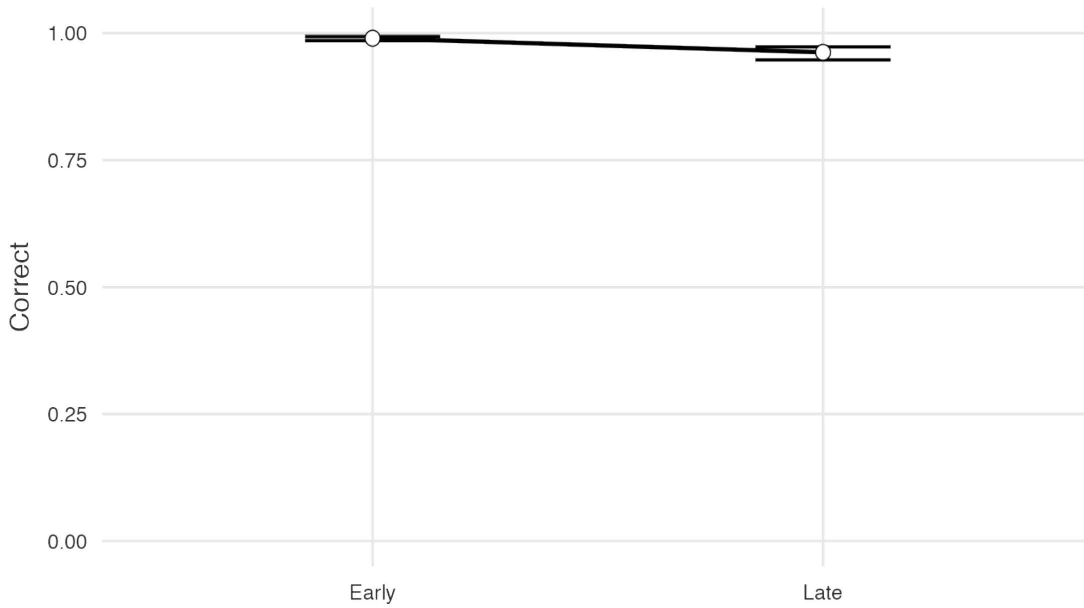

Figure 1: Accuracy Plot By AoA Type

3.2.2 LDT RTs - Lexicality x Length

Due to RT data being continuous, LMMs were used in this analysis. To start with, "lmer" package was used as the model. The model type was selected as Mixed, distribution was selected as Gaussian and the "bobyga" optimizer was used (see Appendix C, Table C3 for more information on model info). Regarding the degrees of freedom, Satterhwaite approximation was used. Fixed factors included in the model were lexicality, length and their interactions. Random factors included were participants and items. Model fit was tested using a likelihood-ratio test which showed that when taking both fixed and random effects, the model provided better fit for the data compared to no model, $\chi 2(11) = 7054.2$, $p < .001$, explaining 31% of the variance. Also, when only fixed effects were taken into consideration, the model again showed significance, $\chi 2(9) = 78.41$, $p > .05$, and the explained variance decreased to 5% (see Table 9) which means that random effects solely explained 26% variance in RTs.

Table 9: Likelihood-Ratio Test for LDT RTs- Lexicality x Length

Type	R^2	*df*	**LRT** $\chi 2$	*p*
Conditional	0.31	11	7054.02	< .001
Marginal	0.05	9	78.41	< .001

The fixed effect omnibus test (see Table 10) showed a significant main effect for lexicality, $F(1, 145.91) = 77.66$, $p < .001$, also a significant main effect for Length observed, $F(4, 145.91) = 3.47$, $p = .010$, but for Length x Lexicality interaction no significant effect was observed, $F(4, 145.91) = 1.22$, $p = .305$.

Table 10: Fixed Effects Omnibus Test LDT RTs - Lexicality x Length

Names	***F***	***df***	***df* (res)**	***p***
Lexicality	77.66	1	145.91	< .001
Length	3.47	4	145.91	0.010
Lexicality * Length	1.22	4	145.91	0.305

Further, parameter estimates for fixed coefficients (see Table 11) showed that actual words have elicited approximately 110 ms faster responses than non- words, β = -110.86, *SE* = 12.58, $t = -8.81$, $p < .001$. Also, 3 letter words have elicited approximately 53 ms faster responses than 6 letter words $\beta = 53.6$, *SE* = 19.89, $t = 2.67$, $p = .008$. Further, 3 letter words have elicited approximately 65 ms faster responses than 7 letter words β = 65.74, *SE* = 19.88, $t = 3.31$, $p < .001$.

Table 11: Parameter Estimates (Fixed coefficients) LDT RTs – Lexicality x Length

Names	Effect	*β*	*SE*	95% CI Lower	95% CI Upper	*df*	*t*	*p*
(Intercept)	(Intercept)	791.51	11.84	768.31	814.72	239.44	66.85	< .001
Lex1	word - NW	-110.86	12.58	-135.51	-86.20	145.91	-8.81	< .001
Length1	4 - 3	19.51	19.88	-19.46	58.49	145.74	0.98	0.328
Length2	5 - 3	36.49	19.89	-2.50	75.47	145.90	1.83	0.069
Length3	6 - 3	53.16	19.89	14.18	92.15	145.92	2.67	0.008
Length4	7 - 3	65.74	19.88	26.77	104.71	145.69	3.31	0.001
Lex1 * Length1	(word - NW) * (4 - 3)	35.16	39.77	-42.79	113.11	145.74	0.88	0.378

Table 11: Parameter Estimates (Fixed coefficients) LDT RTs – Lexicality x Length

Names	Effect	*β*	*SE*	95% CI Lower	95% CI Upper	*df*	*t*	*p*
Lex1 * Length2	(word - NW) * (5 - 3)	39.24	39.78	-38.73	117.21	145.90	0.99	0.326
Lex1 * Length3	(word - NW) * (6 - 3)	-12.92	39.78	-90.90	65.05	145.92	-0.32	0.746
Lex1 * Length4	(word - NW) * (7 - 3)	-32.90	39.76	-110.84	45.04	145.68	-0.83	0.409

Abbreviations: Lex1, Lexicality.

Additionally, Post-Hoc comparisons were done using Bonferroni correction to examine differences between lexicality and length levels in detail (see Table 12). The results indicated that 3 letter words have elicited approximately 116 ms faster responses than 3 letter NW, p = .002., 3 letter words have elicited approximately 118 ms faster responses than 4 letter NW, $p < .001$, approximately 133 ms faster responses than 5 letter NW, $p < .001$, approximately 176 ms faster responses than 6 letter NW, $p < .001$. Moreover, 4 letter words have elicited approximately 96 ms faster responses than 5 letter NW, p = .028. Also, 6 letter NW have elicited approximately 140 ms slower responses than 4 letter words, $p < .001$, approximately 120 ms slower responses than 5 letter words, $p < .001$, approximately 130 ms slower responses than 6 letter words, $p < .001$, approximately 127 ms slower responses than 7 letter words, $p < .001$. Finally, 7 letter NW have elicited approximately 198 ms slower responses than 3 letter words, $p < .001$, approximately 162 ms slower responses than 4 letter words, $p < .001$, approximately 143 ms slower responses than 5 letter words, $p < .001$, approximately 152 ms slower responses than 6 letter words, $p < .001$ and approximately 150 ms slower responses than 7 letter words, $p < .001$. (see Figure 2 for a graphic presentation of mean RTs by Lexicality and Length).

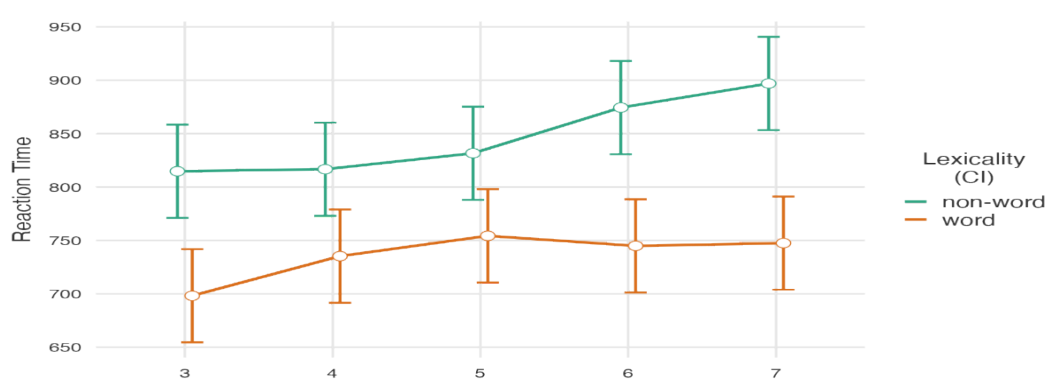

Figure 2: Mean LDT RT Comparisons by Lexicality and Length

Table 12: Post Hoc Comparisons for LDT RTs - Lexicality x Length

Comparison								
Lex	**Length**	**vs**	**Lex**	**Length**	**Difference**	**SE**	***z***	***p*_bonferroni**
NW	3	-	NW	4	-1.93	28.12	-0.07	1.000
NW	3	-	NW	5	-16.87	28.12	-0.60	1.000
NW	3	-	NW	6	-59.62	28.13	-2.12	1.000
NW	3	-	NW	7	-82.19	28.13	-2.92	0.157
NW	3	-	word	3	116.57	28.12	4.15	0.002
NW	3	-	word	4	79.48	28.12	2.83	0.212
NW	3	-	word	5	60.47	28.14	2.15	1.000
NW	3	-	word	6	69.87	28.13	2.48	0.586
NW	3	-	word	7	67.29	28.11	2.39	0.751
NW	4	-	NW	5	-14.93	28.12	-0.53	1.000
NW	4	-	NW	6	-57.69	28.13	-2.05	1.000
NW	4	-	NW	7	-80.25	28.13	-2.85	0.195
NW	4	-	word	3	118.50	28.12	4.21	0.001
NW	4	-	word	4	81.41	28.12	2.89	0.171
NW	4	-	word	5	62.40	28.14	2.22	1.000
NW	4	-	word	6	71.80	28.13	2.55	0.482
NW	4	-	word	7	69.22	28.11	2.46	0.621

NW	5	-	NW	6	-42.76	28.13	-1.52	1.000
NW	5	-	NW	7	-65.32	28.12	-2.32	0.909
NW	5	-	word	3	133.44	28.11	4.75	< .001
NW	5	-	word	4	96.35	28.12	3.43	0.028
NW	5	-	word	5	77.33	28.14	2.75	0.270
NW	5	-	word	6	86.74	28.13	3.08	0.092
NW	5	-	word	7	84.15	28.11	2.99	0.124
NW	6	-	NW	7	-22.56	28.14	-0.80	1.000
NW	6	-	word	3	176.20	28.13	6.26	< .001
NW	6	-	word	4	139.10	28.13	4.94	< .001
NW	6	-	word	5	120.09	28.15	4.27	< .001
NW	6	-	word	6	129.49	28.14	4.60	< .001
NW	6	-	word	7	126.91	28.12	4.51	< .001
NW	7	-	word	3	198.76	28.12	7.07	< .001
NW	7	-	word	4	161.67	28.13	5.75	< .001
NW	7	-	word	5	142.65	28.15	5.07	< .001
NW	7	-	word	6	152.06	28.14	5.40	< .001
NW	7	-	word	7	149.47	28.12	5.32	< .001
word	3	-	word	4	-37.09	28.12	-1.32	1.000
word	3	-	word	5	-56.10	28.14	-1.99	1.000

word	3	-	word	6	-46.70	28.13	-1.66	1.000
word	3	-	word	7	-49.28	28.11	-1.75	1.000
word	4	-	word	5	-19.01	28.15	-0.68	1.000
word	4	-	word	6	-9.61	28.14	-0.34	1.000
word	4	-	word	7	-12.19	28.12	-0.43	1.000
word	5	-	word	6	9.40	28.16	0.33	1.000
word	5	-	word	7	6.82	28.14	0.24	1.000
word	6	-	word	7	-2.58	28.12	-0.09	1.000

3.2.3 LDT RTs - Length x AoA

Model choices were identical to those reported in LDT RTs – Lexicality x Length. Here, fixed factors included in the model were Length (see Appendix C, Table C4), AoA and their interactions with participants and items as random factors. Model fit was tested using a likelihood-ratio test which showed that when taking both fixed and random effects, the model provided better fit for the data compared to no model, $\chi 2(11) = 2953.61$, $p < .001$, explaining 30% of the variance. Moreover, when only fixed effects were taken into consideration, the model still showed significance, $\chi 2(9) = 27.66$, $p = .001$, and the explained variance decreased to 4%. This means that random effects were responsible from 26% of the variance in RTs (see Table 13).

Table 13: Likelihood-Ratio Test for LDT RTs – Length x AoA

Type	R^2	*df*	**LRT** $\chi 2$	*p*
Conditional	0.30	11	2953.61	< .001
Marginal	0.04	9	27.66	0.001

The fixed effect omnibus test reported in Table 14 showed a significant main effect for AoA, $F(1, 67.61) = 21.65$, $p < .001$, but no significant main effect for Length was observed, $F(4, 67.61) = 1.14$, $p = .347$. Similarly, there was no significant Length x AoA interaction, $F(4, 67.61) = 0.92$, $p = .456$.

Table 14: Fixed Effects Omnibus Test LDT RTs - Length x AoA

	F	***df***	***df (res)***	***p***
Length	1.14	4	67.61	0.347
AoA	21.65	1	67.61	< .001
Length * AoA	0.92	4	67.61	0.456

Further, parameter estimates for fixed coefficients (see Appendix D, Table D3) showed that early AoA words have elicited approximately 87 ms faster responses than late AoA words, $\beta = 87.47$, $SE = 18.80$, $t = -8.81$, $p < .001$. No other significant effect was observed. Lastly, Post-Hoc comparisons were done using Bonferroni correction to examine differences between early and late AoA words. The results indicate that early AoA words elicited significantly faster responses than late AoA words, $t(67.61) = -4.65$, $p < .001$ (see Table 15 and Figure 3).

Table 15: Post Hoc Comparisons for LDT RTs - Length x AoA

Comparison							
AoA	**vs**	**AoA**	**Difference**	***SE***	***t***	***df***	$p_{bonferroni}$
Early	-	Late	-87.47	18.80	-4.65	67.61	< .001

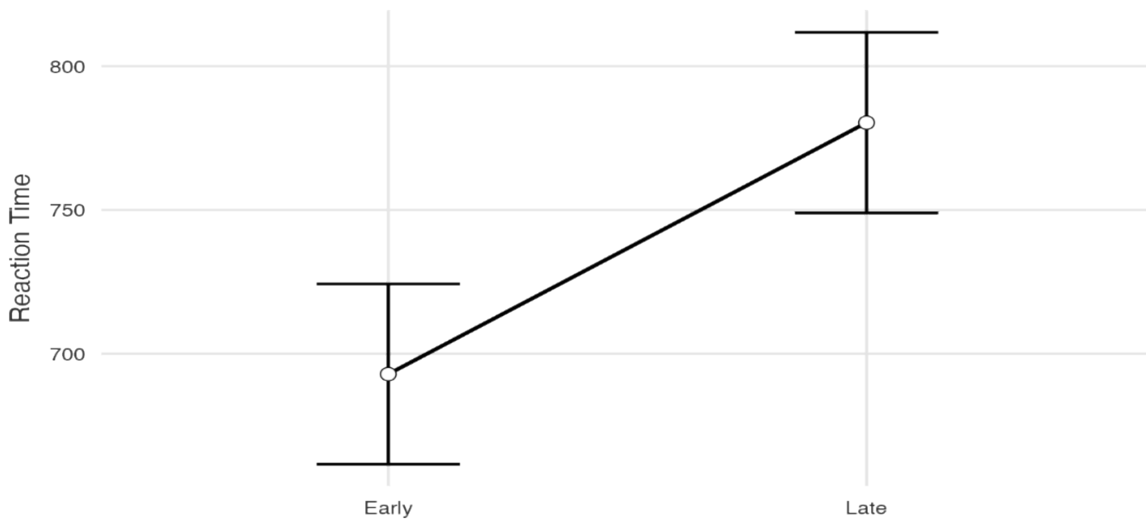

Figure 3: Mean RT Comparisons by AoA

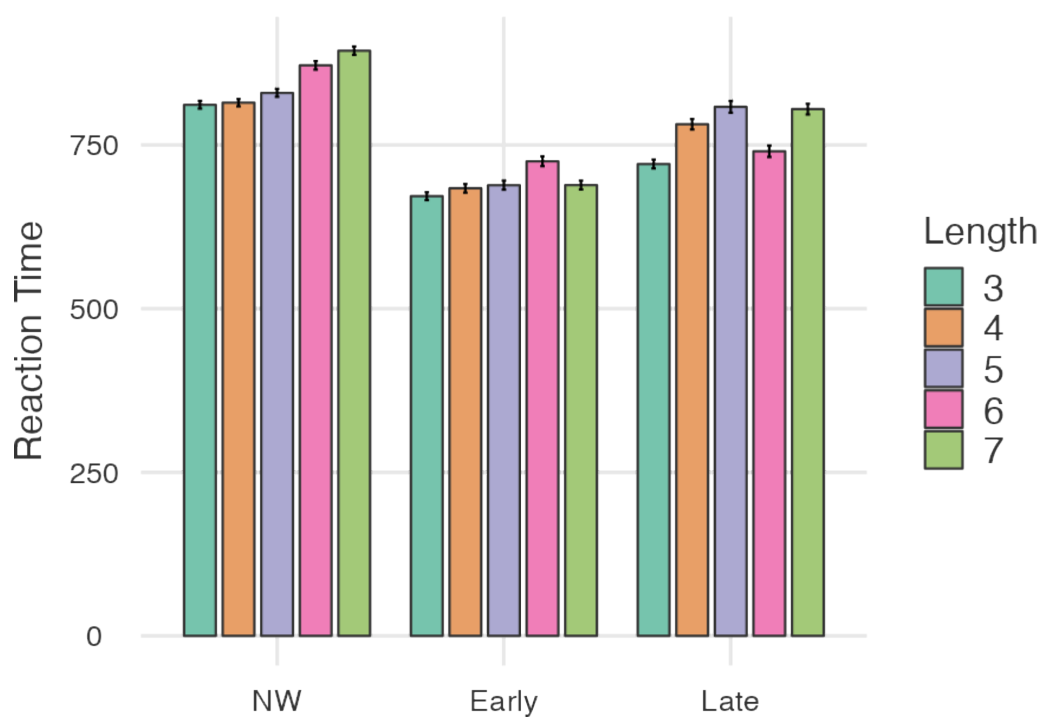

Figure 4: Bar Graph of Reaction Times by Word Types and Length

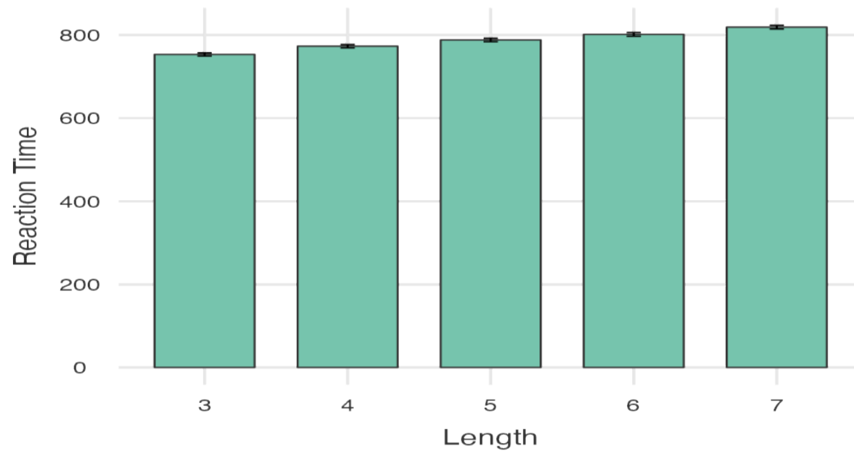

Figure 5: Mean RTs of all Words in LDT by Length

As can be seen from Figure 5, RTs increase in line with letter length in a gradual way when both words and NW are considered.

3.2.4 Validation of the AoA norms for Turkish words (Raman, Raman, E., & Mertan, 2014)

Below Table 16 has descriptives of both Raman et al. (2014) and the current study.

Table 16: Descriptives of Raman, Raman, E., & Mertan (2014) AoA Norm Ratings and the Current Subjective Mean Ratings

Study	N	*M*	Median	*SD*	Minimum	Maximum	Skewness	Kurtosis	*W*
Raman et al. (2014)	80	2.28	2.10	0.63	1.38	3.64	0.25	-1.24	0.93
The current study	80	5.22	5.00	1.89	2.81	10.95	1.02	0.75	0.91

These words' AoA norm ratings plotted against the mean responses obtained from 150 participant to validate the previous norms which was one of the aims of this thesis. The correlation between the current subjective mean ratings and Raman, Raman, E., & Mertan (2014) AoA norm ratings is r = .87, p < .001 (see Figure 6). Based on this correlation, the assumption that norms used in the study are still valid to this day seems plausible.

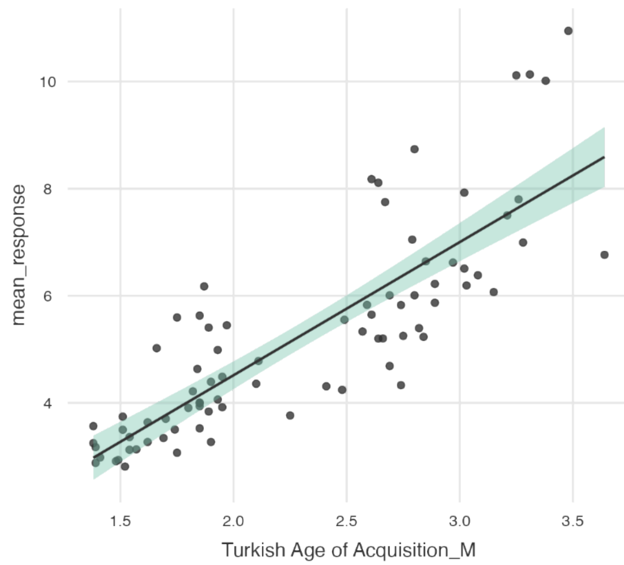

Figure 6: The Current Study Subjective AoA Ratings Plotted Against Raman, Raman, E., & Mertan (2014)'s AoA Norm Ratings Based on 80 Words

Chapter 4

DISCUSSION

The current study aimed to i) examine whether RTs and ii) accuracy would be influenced by the AoA where words' letter length was critically manipulated and iii) affirm the AoA ratings between Raman, Raman, E., & Mertan (2014) norms eleven years after their publication.

It was hypothesized that if AoA indeed mimics word frequency effect as claimed by Raman (2006), then word length effect would significantly influence RTs and accuracy rates for early and late acquired words, as well as NWs in LDT. Indeed, AoA was found to be a significant factor for both RTs and accuracy where participants responded faster and more accurately to early acquired words compared to late acquired words. Insofar as length effect was concerned, it is predicted that each additional letter would significantly influence RTs and accuracy rates for early acquired and late acquired words, as well as NWs in LDT. Although it did not appear as a significant factor in any of the models, reaction times indicated an increment for each additional letter in all experimental conditions except (word/nonword and early/late AoA) for 6-7 letter words under early and late AoA conditions. These findings partially support Weekes' findings (1997) in English where there was no significant length effect was observed for HF words and replicate Kökten and Raman's (2007) findings in Turkish naming task regarding length effects by using LDT. Moreover, no significant interaction was found during the data analyses.

Furthermore, the results showed a strong positive correlation between Raman et al. (2014) AoA norms and subjective ratings obtained in the current study which is taken to indicate the validity between the two measures.

4.1 Lexicality Effects

Lexicality status significantly predicted both accuracy and RTs in the current study which suggests that NWs were identified significantly slower and less accurately than real words (i.e., lexicality effect). This indicates the availability of lexical reading strategy (Pagliuca et al., 2008) which supports the idea that lexical route is the primary route to read all words in Turkish and supports the applicability of the DRC model in Turkish (Coltheart et al., 2001). If lexicality status was not significant, this would indicate all words could be read via the sublexical route (i.e., letter by letter) without any involvement of a mental lexicon. The current findings align with those of past studies (i.e., Bilgin, 2016; Raman, Baluch & Besner, 1996; Raman, 2003; Raman, E., 2021) who report of lexicality effects in Turkish. PDP models fail to explain length and lexicality interactions. Hence, significant lexicality and length findings in Turkish provide further support to past studies regarding the doubts towards PDP models' applicability and validity.

4.2 Length Effects

Contrary to the prediction that letter length would have a significant impact on RTs, the findings did not yield an overall main effect for length. However, two significant differences emerged between 3-7 letter word RTs and 4-7 letter word RTs when lexicality and length were taken into account in explaining the variance in RTs. Arguably, the two findings between the shortest and the longest words were to be expected. Previous studies highlight indicate that syllable length is another significant factor in VWR (Davies et al., 2013), and since, these word conditions differ from each other by at least one syllable, this may contribute to the significant difference between the conditions. It is noteworthy to add here that syllable effects were not the focus of the current study because the correlation between letter and syllable length has been previously reported to be 0.75 (Raman, E., 2021).

Regardless, the steady increase observed in RTs for each additional letter (see Figure 5, end of the results section) resembles Kökten and Raman's (2007) findings regarding RTs by length condition. The similar pattern of results from LDT and naming tasks indicate that the role of letter length on increasing RTs while processing words are independent of orthography since this is evident for both Turkish and English (Balota et al., 2004; Kökten & Raman, 2007). Nonetheless, experimental studies that would use longer words are needed to compare these languages in a broader scope and make more valid theoretical implications.

It is possible that due to the Turkish language being rich in morphology and its agglutinative nature, skilled readers recognize whole words easier or become efficient at recognizing words compared-to other Anglo-centric orthographies such as English or French, as the cognitive system matures in VWR tasks (Zeigler & Goswami, 2005). In this respect Turkish words can be long, and according to Raman E.'s (2021) SUBTLEX-TR data, most frequent words within approximately 925.000 words are 10, 11, and 12 letter words which shows how common long words are in Turkish. Non-significant results obtained regarding word-length effect differences between 3, 4, 5, 6 and 7 words could be explained by this and to see an actual difference, maybe longer word designs (e.g., 10,11, 12,13 and 14) could be implemented in the future studies.

4.3 Lexicality x Length Interaction

Where lexicality and length are concerned, as Figure 2 shows, when only words are considered there seems to be a peak in RT at 5 letter words and after that there seems to be a flat line whereas the increment in RTs for NWs appear to be linear. This clear discrepancy shows that although there is no significant interaction there seems to be an emerging trend that warrants discussion. The effect on RTs being more pronounced for NW compared to real words suggests that serial reading processes of NW using sub-lexical route differs from parallel processes in whole word recognition and skilled Turkish readers can use both sub-lexical and lexical routes for reading. This means that for NWs Turkish readers adapt a letter by letter reading strategy whereas for actual words they might both retrieve the word from the mental lexicon or if it is a novel word they might adapt a letter by letter reading strategy too. Theoretically, the small word length effect indicates the serial composition of the sub-lexical route in VWR (Coltheart et al., 2021) , which is in line with previous studies in Turkish (Raman, 2006; Raman & Baluch, 2001; Raman, Baluch & Besner, 2004). Further, this finding provides further evidence to the PGST and the universal hypothesis which proposes that both lexical and sub-lexical mappings could be utilized simultaneously in a transparent orthography, and in turn presents robust issues to the strong view of the Orthographic Depth Hypothesis (Ziegler & Goswami, 2005).

4.4 AoA Effects

To validate the AoA norms used in the study (Raman, Raman, E., & Mertan, 2014) subjective AoA ratings were obtained and compared with the previous norms. The results showed a reasonably high Spearman correlation value (r = .87) which suggest that although 11 years have passed the norms are valid and could be used in further psycholinguistics studies in Turkish. Previous studies have already established the fact that adults are good at providing AoA estimates, although they don't have good recollection abilites regarding childhood or infancy years which is called "childhood amnesia" (Pathman et al., 2013). Hence, the current finding regarding the correlation between two AoA ratings are not surprising. Moreover, using a scale when collecting AoA norms was found to be restrictive factor (Kuperman et al., 2012) hence AoA ratings for the current study were obtained via open-ended responses. Though the previous norms were obtained using a 5 point likert scale, the results show that when participants give an open ended response for AoA, there is still a high correlation between the two measures. Also other descriptives measures were in line between both studies (see Table 20, Reuslts section). Mean values in the Raman et al. (2014) are 2.28 while it is 5.22 in the current study. These values actually correspond since in likert scale values a score of 1 represents the ages of zero and three years, 2 between four and six years, 3 between seven and nine years, 4between ten and twelve years, and 5 thirteen years or more. Considering that 2 corresponds to between four and six years, 2.28 nearly corresponds to the mean value 5.22 obtained in the current study.

Early acquired words showed a significant RT advantage compared to late acquired words and it is further evidence that AoA is a central psycholinguistic factor in the mental lexicon. The results add support to previous AoA findings in Turkish (Raman, 2006, 2011; Raman, Raman, E., İkier et al., 2018; Kilecioğlu et al., 2022). Theories that try to explain AoA effect such as representation theory (Brysbaert & Ghyselinck, 2006), multiple loci account (Catling & Johnston, 2006a, 2006b, 2006c) and the mapping theory (Monaghan & Ellis, 2002) argues that significant AoA effects should come out from LDT data. Particularly, Ellis and Lambon Ralph (2000) argue larger AoA effects in naming than LDT in English are due to arbitrary mapping between orthography and phonology. However, strong AoA effects found in a highly transparent orthography like Turkish forms a solid criticism to the arbitrary-mapping hypothesis (Ellis & Lambon Ralph, 2000). It is not plausible to attribute AoA effects to irregularity or unpredictability of mappings between representations considering the current results from a task like LDT which relies more on semantic processes. Previous findings from other transparent languages like Spanish and Italian also provide support to this notion (Spataro et al., 2013a, 2013b). Further, using their connectionist model Zevin and Seidenberg (2002) have claimed that in highly transparent ortographies where GPCs are consistent and systematic, AoA effects should be null because the actual effect here is cumulative frequency effects. Again, findings pose a robust criticism to this claim and model. According to the representation theory, AoA effects should be more pronounced in LDT compared to naming tasks since semantic processes are more active in LDT than naming. Representation theory (Monaghan & Ellis, 2002) also suggests that AoA effects should be stronger than frequency effects, again due to the heavy involvement of semantic processes. Indeed, it was expected that AoA would mimic frequency effect when reading in Turkish and the current results suggest that AoA effects could actually be frequency dependent as the representation theory suggests. Nevertheless, to test these theories further, researchers should use both LDT and naming task to get a more comprehensive account of AoA effects. Due to differences between two tasks such as the involvement of phonology in naming tasks make it possible to test and compare AoA theories in detail.

4.5 Limitations and Future Directions

Naturally, it is not possible for a simple task to provide a comprehensive view on VWR because each specific task has a specific way of measuring variable of interests. For example, NT requires an additional reading aloud part compared to LDT and consequently provides greater information regarding phonology's role in reading. Hence, the best course of action to conduct comprehensive and rigorous research on VWR is to combine multiple tasks such as NT and LDT so that comparisons and differences between the tasks' outcome can shed light on the processes involved in it. Relatedly, the current study originally planned to involve a NT in addition to LDT, however due to technical difficulties and the limited time period during experiment building, NT was removed from the study.

Typical of research in this area, a main limitation was the use of factorial design with a limited size of the available norms and therefore stimuli. Although the current study's NW were created by a NW generator algorithm, still all words have been chosen by the experimenter, hence familiarity was not controlled for which migth affect LDT.. Further, list context effects are very much possible within this approach and this might affect a certain stimulus' processing due to semantic and phonological connections between words (Monsell et al., 1992; Zevin & Balota, 2000).

To tackle the issues stemming from factorial design, there has been a serious trend towards a mega study approach (Balota et al., 2012; Brysbaert & Biemiller 2016; Ferrand et al., 2010; Keuleers et al., 2012; Keuleers & Balota, 2015; Kuperman et al., 2012 Mandera et al., 2020; Sze et al., 2017). With this approach, a large number of stimuli (e.g., 40.418 words for English Lexicon Project, Balota et al., 2007) were used in the LDT and naming tasks, resulting in enourmous data sets which enable researchers to explore different psycholinguistic variables' effect on VWR. Here, researchers do not have to deal with matching the experimental materials on confounding variables, rather each variable can be separately included in the regression analyses (Soares et al., 2019). This design also allows researchers to eliminate categorical classification for variables of interest (e.g., early vs late AoA). Instead, the actual values obtained from LDTs could be directly used in continuous analyses of variables and these variables could be investigated across their whole range. All these factors increase the reliability of experimental results, increase the statistical power of studies, and reduce experimenter bias in stimuli selection (Brysbaert et al., 2016). Additionally, this approach permits researchers to investigate nonlinear effects (Balota et al., 2004) and allows analyses to be carried out using the same data set to test additional hypotheses or explorations for new hypotheses. Considering all of these, a mega study approach will provide the biggest psycholinguistic data set in Turkish so far and substantial insights and theoretical considerations could be made accordingly. Therefore, a mega study in Turkish that uses either one of the LDT or naming task or both would be the best course of action in terms of improving the quality and quantity of Turkish psycholinguistic research and by doing so it would be possible to see each significant variable of interest's (e.g., familiarity, concreteness) independent contribution to skilled reading in Turkish. To test the current reading theories further, researchers could use both LDT and naming task to get a more comprehensive account of AoA effects.

In terms of age, the current study recruited skilled native Turkish readers who were 18 years and older (age range was between 18 – 56 years), hence the results cannot be generalized to skilled readers younger than 18 years of age or to older adults (65 years

+). Furthermore, almost all participants were either EMU students or EMU staff which indicates that they either have received higher education or are part of a higher education system which limits the characteristics of the sample. Future studies should implement more comprehensive research designs regarding the demographics and recruit data from a more inclusive sample. Including children and older people and dividing participants into different age groups could provide further information to current theories and issues in VWR.

4.6 Conclusion

The current study had a relatively small scope, nonetheless findings provided cruical insights for both Turkish psycholinguistic research area and VWR research on isolated words by skilled readers. Considering length, partially replicating results from English and replicating the results for Turkish contributed to the existing body of knowledge. It seems that the two-route approach in the DRC model is applicable for reading in Turkish due to the significant RT differences between words and NWs. In terms of AoA the results were in line with previous Turkish studies and this solidifed the notion that even in extremely transparent orthographies AoA acquisition effects are evident and robust. The results imply that AoA effects might mimic frequency and could be at least partially dependent on frequency effects.

As repeatedly mentioned, Turkish is the most transparent orthography that is known and at the same time it is morphologically one of the richest languages in the world. These two outlier aspects of Turkish make the language particularly interesting and extremely important for psycholinguistics research due to its potential to inform and update the current theories of reading. Furthermore, this study was one of the few studies in the Turkish psycholinguistic literature that have used more advanced and up to date statistical analyses. LMM has the statistical power over an ANOVA and it is recommended that future researchers also utilize such statistical analyses in their research designs. For Turkish VWR research it is recommended that Turkish psycholinguistic researchers expand the current norms in terms of number and variables such as familiarity and contextual diversity and conducting more comprehensive and large-scale studies such as mega studies or crowdsourcing study.

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APPENDICES

Appendix A: Experimental Stimuli in LDT

Word	Type	No of Letters	Condition	Mean AoA
fil	word	3	3E	1,48
göz	word	3	3E	1,54
top	word	3	3E	1,57
muz	word	3	3E	1,62
kol	word	3	3E	1,75
kuş	word	3	3E	1,85
kek	word	3	3E	1,90
saç	word	3	3E	2,10
fiş	word	3	3L	2,11
taç	word	3	3L	2,25
dağ	word	3	3L	2,69
çit	word	3	3L	2,64
zil	word	3	3L	2,59
mum	word	3	3L	2,49
ayı	word	3	3L	2,48
ütü	word	3	3L	2,41
mur	non-word	3	3NW	
taz	non-word	3	3NW	
saş	non-word	3	3NW	

daç	**non-word**	**3**	**3NW**	
üti	**non-word**	**3**	**3NW**	
tot	**non-word**	**3**	**3NW**	
tağ	**non-word**	**3**	**3NW**	
koğ	**non-word**	**3**	**3NW**	
göş	**non-word**	**3**	**3NW**	
sab	**non-word**	**3**	**3NW**	
fip	**non-word**	**3**	**3NW**	
keç	**non-word**	**3**	**3NW**	
dap	**non-word**	**3**	**3NW**	
zit	**non-word**	**3**	**3NW**	
ziş	**non-word**	**3**	**3NW**	
fiç	**non-word**	**3**	**3NW**	
eşek	**word**	**4**	**4E**	**1,41**
kase	**word**	**4**	**4E**	**1,54**
elma	**word**	**4**	**4E**	**1,66**
kapı	**word**	**4**	**4E**	**1,69**
ağaç	**word**	**4**	**4E**	**1,74**
ahır	**word**	**4**	**4E**	**1,80**
kedi	**word**	**4**	**4E**	**1,85**
ayak	**word**	**4**	**4E**	**1,87**
puro	**word**	**4**	**4L**	**2,69**
deve	**word**	**4**	**4L**	**2,84**

vida	**word**	**4**	**4L**	**2,89**
kuyu	**word**	**4**	**4L**	**3,02**
pipo	**word**	**4**	**4L**	**3,21**
kask	**word**	**4**	**4L**	**3,25**
çapa	**word**	**4**	**4L**	**3,38**
iğne	**word**	**4**	**4L**	**3,64**
dete	**non-word**	**4**	**4NW**	
ağak	**non-word**	**4**	**4NW**	
keve	**non-word**	**4**	**4NW**	
deda	**non-word**	**4**	**4NW**	
keda	**non-word**	**4**	**4NW**	
pipa	**non-word**	**4**	**4NW**	
kuro	**non-word**	**4**	**4NW**	
vipo	**non-word**	**4**	**4NW**	
çask	**non-word**	**4**	**4NW**	
puyu	**non-word**	**4**	**4NW**	
kapu	**non-word**	**4**	**4NW**	
iğaç	**non-word**	**4**	**4NW**	
ayaç	**non-word**	**4**	**4NW**	
pida	**non-word**	**4**	**4NW**	
eşet	**non-word**	**4**	**4NW**	
ağne	**non-word**	**4**	**4NW**	
burun	**word**	**5**	**5E**	**1,39**

bebek	**word**	**5**	**5E**	**1,38**
kulak	**word**	**5**	**5E**	**1,38**
ampul	**word**	**5**	**5E**	**1,39**
ekmek	**word**	**5**	**5E**	**1,62**
balon	**word**	**5**	**5E**	**1,51**
güneş	**word**	**5**	**5E**	**1,49**
dudak	**word**	**5**	**5E**	**1,75**
keski	**word**	**5**	**5L**	**2,75**
silah	**word**	**5**	**5L**	**2,80**
törpü	**word**	**5**	**5L**	**2,82**
kilit	**word**	**5**	**5L**	**3,02**
çekiç	**word**	**5**	**5L**	**3,03**
paten	**word**	**5**	**5L**	**3,08**
kızak	**word**	**5**	**5L**	**3,28**
goril	**word**	**5**	**5L**	**3,31**
çeski	**non-word**	**5**	**5NW**	
günek	**non-word**	**5**	**5NW**	
patek	**non-word**	**5**	**5NW**	
dulak	**non-word**	**5**	**5NW**	
günen	**non-word**	**5**	**5NW**	
bekil	**non-word**	**5**	**5NW**	
kudak	**non-word**	**5**	**5NW**	
baten	**non-word**	**5**	**5NW**	

silil	**non-word**	**5**	**5NW**	
dudah	**non-word**	**5**	**5NW**	
çekit	**non-word**	**5**	**5NW**	
beski	**non-word**	**5**	**5NW**	
kekit	**non-word**	**5**	**5NW**	
kilah	**non-word**	**5**	**5NW**	
palon	**non-word**	**5**	**5NW**	
çebek	**non-word**	**5**	**5NW**	
bardak	**word**	**6**	**6E**	**1,51**
yıldız	**word**	**6**	**6E**	**1,52**
tabure	**word**	**6**	**6E**	**1,85**
karpuz	**word**	**6**	**6E**	**1,89**
kanepe	**word**	**6**	**6E**	**1,90**
gözlük	**word**	**6**	**6E**	**1,93**
parmak	**word**	**6**	**6E**	**1,95**
fincan	**word**	**6**	**6E**	**1,97**
sigara	**word**	**6**	**6L**	**2,66**
maymun	**word**	**6**	**6L**	**2,74**
ananas	**word**	**6**	**6L**	**2,74**
baykuş	**word**	**6**	**6L**	**2,85**
çıkrık	**word**	**6**	**6L**	**2,89**
piyano	**word**	**6**	**6L**	**3,15**
kilise	**word**	**6**	**6L**	**3,26**

zincir	**word**	**6**	**6L**	**3,48**
zincan	**non-word**	**6**	**6NW**	
maykuş	**non-word**	**6**	**6NW**	
fincir	**non-word**	**6**	**6NW**	
barpuz	**non-word**	**6**	**6NW**	
çıkrım	**non-word**	**6**	**6NW**	
barmak	**non-word**	**6**	**6NW**	
parpuz	**non-word**	**6**	**6NW**	
fincap	**non-word**	**6**	**6NW**	
sitare	**non-word**	**6**	**6NW**	
pabure	**non-word**	**6**	**6NW**	
silise	**non-word**	**6**	**6NW**	
kardas	**non-word**	**6**	**6NW**	
piyane	**non-word**	**6**	**6NW**	
baymun	**non-word**	**6**	**6NW**	
kardak	**non-word**	**6**	**6NW**	
pardak	**non-word**	**6**	**6NW**	
şeftali	**word**	**7**	**7E**	**1,70**
domates	**word**	**7**	**7E**	**1,82**
anahtar	**word**	**7**	**7E**	**1,84**
telefon	**word**	**7**	**7E**	**1,85**
kelebek	**word**	**7**	**7E**	**1,85**
patates	**word**	**7**	**7E**	**1,89**

uçurtma	**word**	**7**	**7E**	**1,93**
karınca	**word**	**7**	**7E**	**1,95**
merdane	**word**	**7**	**7L**	**2,57**
testere	**word**	**7**	**7L**	**2,61**
kokarca	**word**	**7**	**7L**	**2,61**
penguen	**word**	**7**	**7L**	**2,64**
ıstakoz	**word**	**7**	**7L**	**2,67**
kanguru	**word**	**7**	**7L**	**2,79**
kereviz	**word**	**7**	**7L**	**2,80**
enginar	**word**	**7**	**7L**	**2,97**
ıstakot	**non-word**	**7**	**NW**	
kokates	**non-word**	**7**	**NW**	
telebek	**non-word**	**7**	**NW**	
kokurca	**non-word**	**7**	**NW**	
komatma	**non-word**	**7**	**NW**	
kanguen	**non-word**	**7**	**NW**	
kelefon	**non-word**	**7**	**NW**	
penguru	**non-word**	**7**	**NW**	
merdani	**non-word**	**7**	**NW**	
telefoz	**non-word**	**7**	**NW**	
kerdane	**non-word**	**7**	**NW**	
mereviz	**non-word**	**7**	**NW**	
şertali	**non-word**	**7**	**NW**	

domarca	**non-word**	**7**	**NW**	
ıstates	**non-word**	**7**	**NW**	
patakoz	**non-word**	**7**	**NW**	
çiçek	**word**	**5**	**Practice**	
perde	**word**	**5**	**Practice**	
kitap	**word**	**5**	**Practice**	
bardak	**word**	**6**	**Practice**	
yıldız	**word**	**6**	**Practice**	
belom	**non-word**	**5**	**Practice**	
garik	**non-word**	**5**	**Practice**	
zelvar	**non-word**	**6**	**Practice**	
pundik	**non-word**	**6**	**Practice**	
tıraki	**non-word**	**6**	**Practice**	

Appendix B: Ethics Approval Document

Eastern Mediterranean University

Social, Humanities and Administrative Sciences Ethics Subcommittee

21 January 2025

ETK00-2025-0002

Dear Mehmet Aslan,

I am pleased to inform you that your ethics application for your project titled **Exploring the effect of age of acquisition on number of letters on word and nonword naming and lexical decision RTs in Turkish** under the supervison of Prof. Dr. Ilhan Raman has been approved and you can start data collection.

With all good wishes,

Assist. Prof. Dr. Pelin Karakuş Akalın

Member, EMU Social Sciences, Humanities and Administration (SOBIB) Ethics Subcommittee

Appendix C: Additional Tables and Figures from LMM Analyses

Table C1: Model Info on Generalized Mixed Model for Accuracy - Lexicality x Length

Info		
Model Type	Logistic Model	Model for binary y
Model	lme4::glmer	Correct ~ 1 + Lexicality + Length + Lexicality:Length + (1 | Participant Private ID) + (1 | Stimulus)
Distribution	Binomial	Dichotomous event distribution of y
Link function	Logit	Log of the odd of y
Direction	P(y=1)/P(y=0)	P(Correct = 1) / P(Correct = 0)
Sample size	23861	
Converged	yes	
C.I. method	Wald	

Table C2: Model Info on Generalized Mixed Model for Accuracy – Length x AoA

Info		
Model Type	Logistic Model	Model for binary y
Model	lme4::glmer	Correct ~ 1 + Length + AoA_clean + Length:AoA_clean + (1 | Participant Private ID) + (1 | Stimulus)
Distribution	Binomial	Dichotomous event distribution of y
Link function	Logit	Log of the odd of y
Direction	P(y=1)/P(y=0)	P(Correct = 1) / P(Correct = 0)
Sample size	11948	
Converged	yes	

Table C2: Model Info on Generalized Mixed Model for Accuracy – Length x AoA

Info	
C.I. method	Wald

Table C3: Model Info on Linear Mixed Model for Accuracy – Lexicality x Length

Info		
Model Type	Mixed Model	Linear Mixed model for continuous y
Model	lmer	\`Reaction Time\` ~ 1 + Lexicality + Length + Lexicality:Length + (1 | Participant Private ID) + (1 | Stimulus)
Distribution	Gaussian	Normal distribution of residuals
Direction	y	Dependend variable scores
Optimizer	bobyqa	
DF method	Satterthwaite	
Sample size	22736	
Converged	yes	
Y transform	none	
C.I. method	Wald	

Table C4: Model Info on Linear Mixed Model for Accuracy – Lexicality x AoA

Info		
Model Type	Mixed Model	Linear Mixed model for continuous y
Model	lmer	\`Reaction Time\` ~ 1 + Length + AoA_New + Length:AoA_New + (1 | Participant Private ID) + (1 | Stimulus)
Distribution	Gaussian	Normal distribution of residuals

Table C4: Model Info on Linear Mixed Model for Accuracy – Lexicality x AoA

Info		
Direction	y	Dependend variable scores
Optimizer	bobyqa	
DF method	Satterthwaite	
Sample size	11392	
Converged	yes	
Y transform	none	
C.I. method	Wald	

Table C5: *Parameter Estimates (Fixed coefficients) LDT Accuracy – Lexicality x Length*

					95% Confidence Intervals			
Names	**Effect**	***β***	**SE**	**Exp(*β*)**	**Lower**	**Upper**	***z***	***p***
(Intercept)	(Intercept)	3.62	0.10	37.28	30.50	45.58	35.29	< .001
Lexicality1	word - NW	0.37	0.16	1.45	1.06	1.99	2.34	0.019
Length1	4 - 3	-0.20	0.25	0.82	0.50	1.34	-0.81	0.420
Length2	5 - 3	-0.25	0.25	0.78	0.48	1.27	-0.99	0.321
Length3	6 - 3	-0.18	0.25	0.84	0.51	1.37	-0.71	0.475
Length4	7 - 3	-0.01	0.25	0.99	0.60	1.63	-0.04	0.968
Lexicality1 * Length1	(word - NW) * (4 - 3)	-0.35	0.50	0.70	0.26	1.87	-0.70	0.482
Lexicality1 ✻ Length2	(word - NW) ✻ (5 - 3)	-0.79	0.50	0.45	0.17	1.20	-1.59	0.112
Lexical4zity1 ✻ Length3	(word - NW) ✻ (6 - 3)	0.37	0.50	1.44	0.54	3.86	0.73	0.467

Lexicality1 ✻ Length4	(word - NW) ✻ (7 - 3)	0.37	0.50	1.45	0.54	3.90	0.74	0.461

Table C6: Parameter Estimates (Fixed coefficients) LDT Accuracy – AoA x Length

					95% Confidence Intervals			
Names	**Effect**	***β***	**SE**	**Exp(*β*)**	**Lower**	**Upper**	***z***	***p***
(Intercept)	(Intercept)	3.91	0.14	50.03	37.79	66.24	27.32	< .001
Length1	4 - 3	-0.33	0.38	0.72	0.34	1.53	-0.85	0.395
Length2	5 - 3	-0.57	0.38	0.56	0.27	1.20	-1.49	0.135
Length3	6 - 3	0.00	0.39	1.00	0.47	2.16	0.01	0.992
Length4	7 - 3	0.21	0.39	1.23	0.57	2.65	0.52	0.601
AoA	Late - Early	-1.35	0.25	0.26	0.16	0.42	-5.50	< .001
Length1 * AoA	(4 - 3) * (Late - Early)	-0.47	0.77	0.62	0.14	2.81	-0.61	0.539
Length2 * AoA	(5 - 3) * (Late - Early)	-0.89	0.76	0.41	0.09	1.84	-1.16	0.246
Length3 * AoA	(6 - 3) * (Late - Early)	0.09	0.78	1.09	0.24	5.01	0.11	0.909
Length4 * AoA	(7 - 3) * (Late - Early)	-0.16	0.78	0.85	0.18	3.95	-0.21	0.835